OCR
Oxford Cambridge and RSA

Thursday 15 October 2020 – Morning

AS Level Physics A

H156/02 Depth in physics

Time allowed: 1 hour 30 minutes

You must have:
- the Data, Formulae and Relationships Booklet

You can use:
- a scientific or graphical calculator
- a ruler (cm/mm)

* 8 1 9 0 3 8 8 1 9 9 *

* H 1 5 6 0 2 *

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*****).
- This document has **24** pages.

ADVICE
- Read each question carefully before you start your answer.

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Answer **all** the questions.

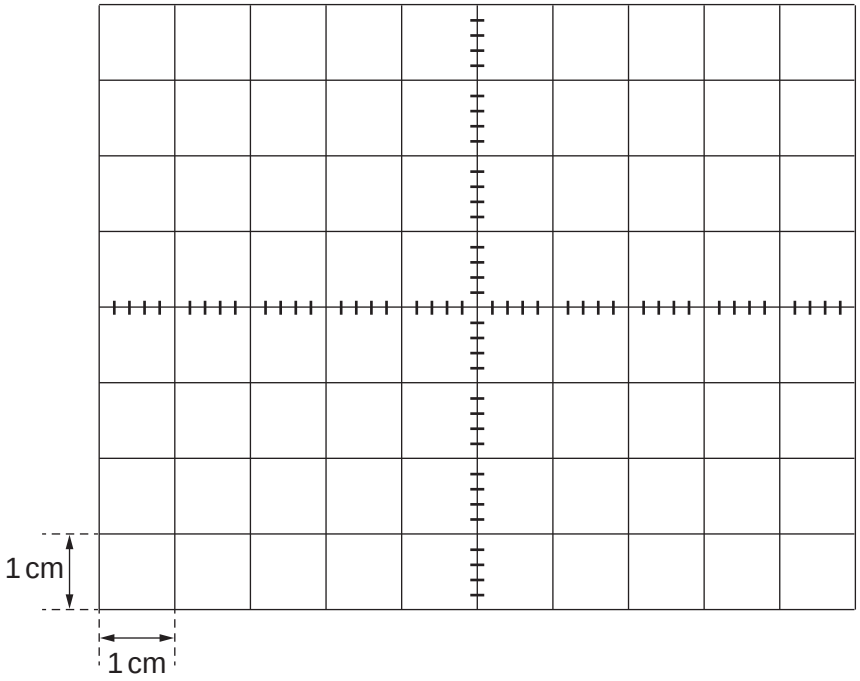
1 **(a)** A sound wave is an example of a longitudinal wave.

(i) State what is meant by the term **longitudinal** wave.

.....

..... **[1]**

(ii) A microphone is connected to an oscilloscope. Sound of frequency 500 Hz is incident on the microphone.
The oscilloscope time-base is set to 0.5 ms cm^{-1} and the *y*-gain set to 1.0 mV cm^{-1}.
The signal displayed on the oscilloscope screen has an amplitude of 2.0 mV.
The oscilloscope grid is shown below.



Sketch the oscilloscope trace on the grid above. **[2]**

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(b) Microwaves and X-rays are examples of electromagnetic waves.

(i) The following are possible wavelengths of electromagnetic waves.

0.2 km 2 m 2 cm 0.2 mm 2 μm 200 nm 200 pm

Select from the list above a typical wavelength of a microwave and an X-ray.

microwave .....

X-ray .....

[2]

(ii) One property of electromagnetic waves is that they are transverse waves.

State **two** other properties.

1. .....

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2. .....

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[2]

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2 **(a)** The table shows the refractive index n of air and glass for blue light. It also shows the speed v and the wavelength λ of blue light in air.

	air	**glass**
refractive index n	1.00	1.53
speed of light v / m s^{-1}	3.00×10^{8}	
wavelength λ / m	4.69×10^{-7}	

(i) Show that the frequency f of blue light in air is 6.40×10^{14} Hz.

[1]

(ii) Complete the table by determining the missing values for v and λ for glass.
Write your answers to 3 significant figures.

[2]

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(b) A semi-circular block of glass is placed in air.
Fig. 2.1 shows the path of blue light through the air and the semi-circular glass block.

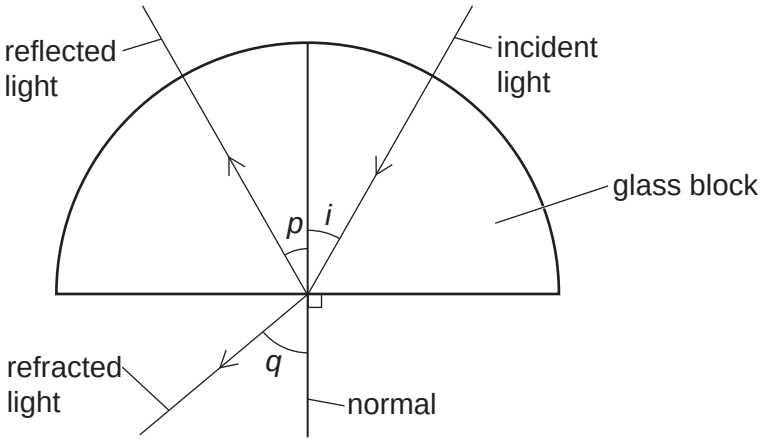

Fig. 2.1 (not to scale)

(i) The angle *i* is 30°.

1. Determine angle *p*.

p = ... ° **[1]**

2. Determine angle *q*, using the information from the table in **(a)**.

q = ... ° **[2]**

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(ii) The angle *i* is increased from 30° to 60°.
Describe and explain how angles *p* and *q* will change. In your answer, include the term **critical angle**.

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..... **[4]**

(c) **Fig. 2.2** shows the same semi-circular glass block with the blue light replaced by red light.

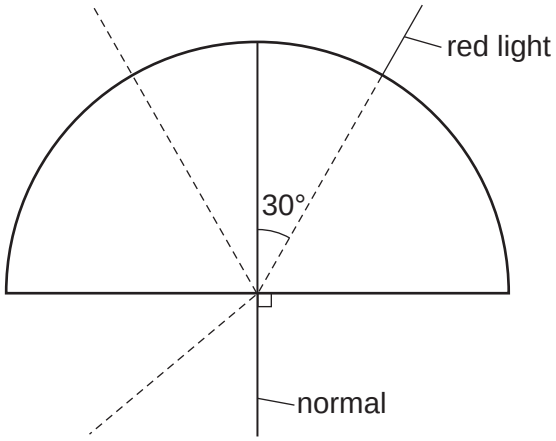

Fig. 2.2 (not to scale)

The dashed lines show the original paths of the blue light.
Draw on **Fig. 2.2** the path of the red light in the glass block and out of the glass block. **[2]**

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3 **Fig. 3.1** shows an experiment to investigate the extension of two identical springs connected side by side. A student uses a 30 cm ruler to measure the length L_0 of the two-spring combination without a load attached.

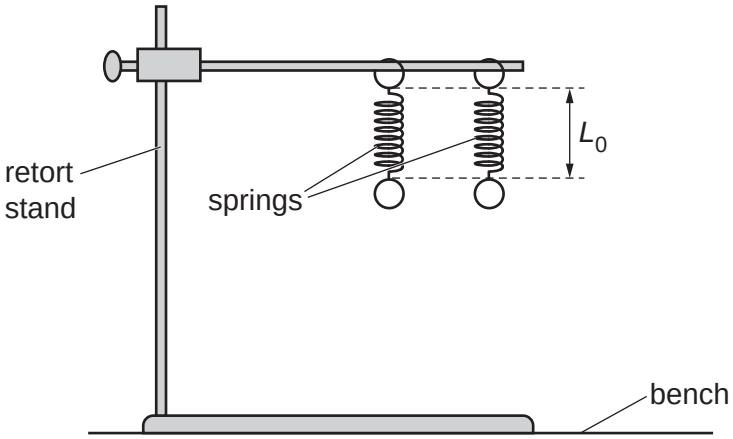

Fig. 3.1

The student then adds a rod and a mass *M* to the spring combination as shown in **Fig. 3.2**.

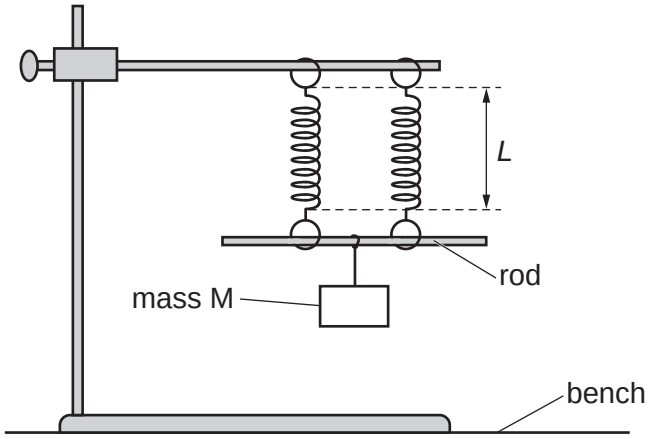

Fig. 3.2

The student then repeats the experiment for different values of *M*. For each value of *M*, the student determines the extension *x* of the spring combination and the absolute uncertainty in *x*.

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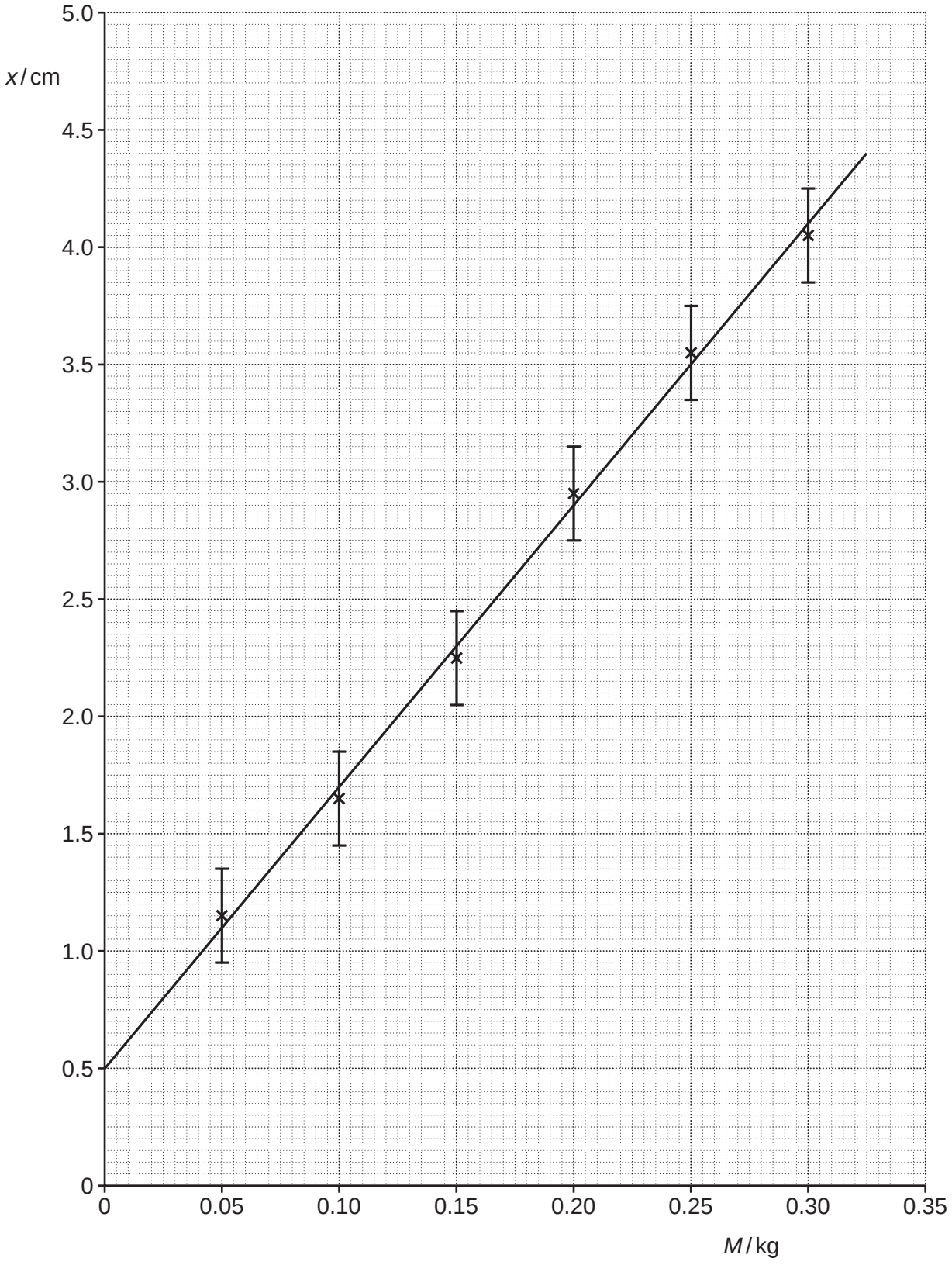
The student plots a graph of extension x (y-axis) against mass M (x-axis) including error bars in x. The straight line of best fit is drawn.



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It is suggested that the relationship between x and M is

$$x = \frac{Mg}{k} + R$$

where k is the force constant of the spring combination, g is the acceleration of free fall and R is a constant.

(a) (i) Show that the gradient of the straight line of best fit is about $0.12\,\text{m}\,\text{kg}^{-1}$.

[2]

(ii) Using the gradient, determine a value for k.
Give your answer to an appropriate number of significant figures and include an appropriate unit.

k = ... unit ..... **[2]**

(b) (i) Draw a worst acceptable straight line. **[1]**

(ii) Determine the gradient of your worst acceptable line.

gradient of worst acceptable line = ... $\text{m}\,\text{kg}^{-1}$ **[1]**

(iii) Determine the percentage uncertainty in k.

percentage uncertainty = ... % **[2]**

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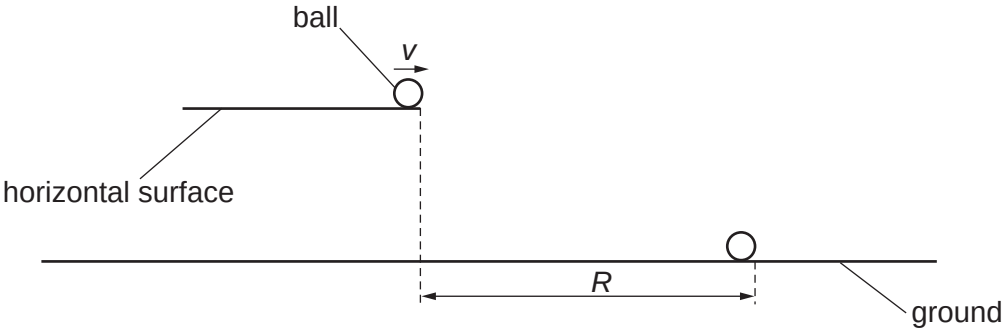
4* A metal ball leaves a horizontal surface with velocity v.
A student investigates the horizontal distance R that the ball travels before it hits the ground.



It is suggested that the relationship between R and v is given by

$$R = v\sqrt{\frac{Q}{g}}$$

where g is the acceleration of free fall and Q is a constant.

Describe with the aid of a suitable diagram how an experiment can be safely conducted, and how the data can be analysed, to determine Q. **[6]**

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Additional answer space if required

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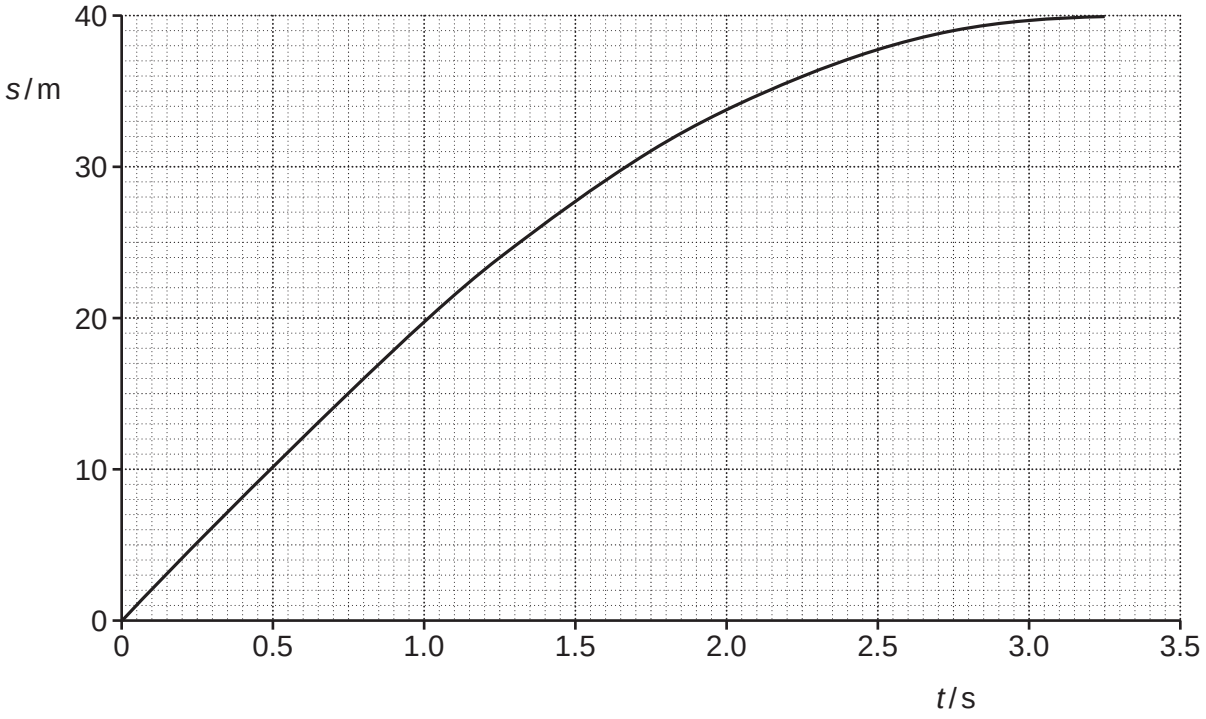
5 A car is travelling at a constant speed of 20 m s^{-1} along a straight road.
The driver sees a hazard ahead in the road, applies the brakes and brings the car to a stop.
The graph below shows the displacement *s* against time *t* for the car from the time that the driver sees the hazard to when the car stops.



The braking force *F* acting on the car is constant.
The mass of the car is 950 kg.
The reaction time of the driver is 0.75 s.

(a) State the gradient of the graph when *t* = 0.

gradient = ... m s^{-1} **[1]**

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(b) Explain how you can deduce from the graph that the brakes are applied at time $t = 0.75\,s$.

.....

.....

..... **[2]**

(c) Draw a tangent to the graph at time $t = 1.75\,s$.
Use this tangent to show that the speed of the car at $t = 1.75\,s$ is about $12\,m\,s^{-1}$.

[2]

(d) Determine the braking force F.
You may use information from **(c)** or from the graph.

$F =$ ..... N **[3]**

(e) Describe and explain the variation of the displacement with time when the same driver applies the brakes in the same car when the initial speed of the car is $10\,m\,s^{-1}$.

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..... **[3]**

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6 **Fig. 6.1** shows a uniform metal cylinder of weight 7.0 N. The cylinder has length 100 mm and diameter 32 mm.

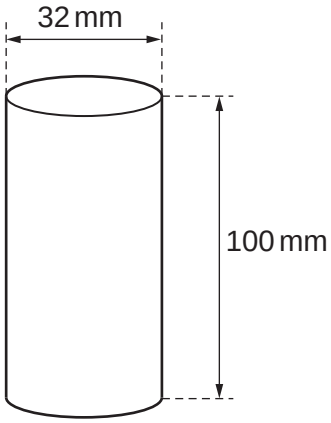

Fig. 6.1 (not to scale)

(a) Calculate the density ρ of the metal.

ρ = ... kg m^{-3} **[3]**

(b) The cylinder is suspended by two cords **A** and **B**, attached to the centre of the top surface, as shown in **Fig. 6.2**.

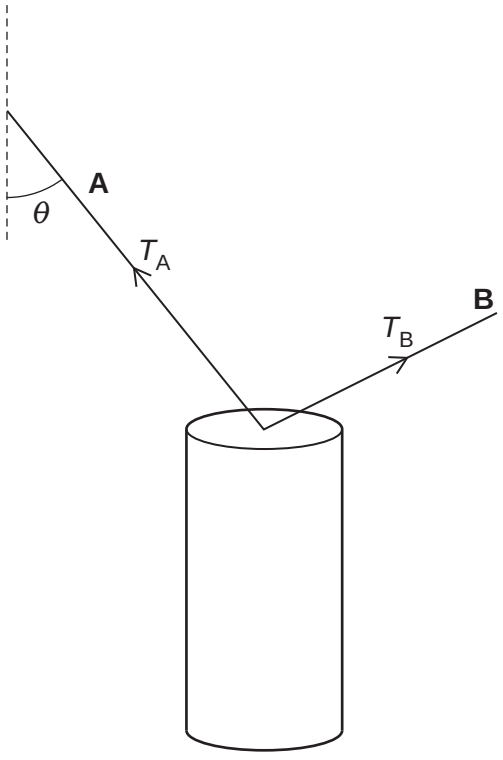

Fig. 6.2 (not to scale)

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The tensions in each of the cords are T_A and T_B.

Fig. 6.3 shows T_B drawn to scale on graph paper.

Scale 1.0 cm represents 2.0 N.

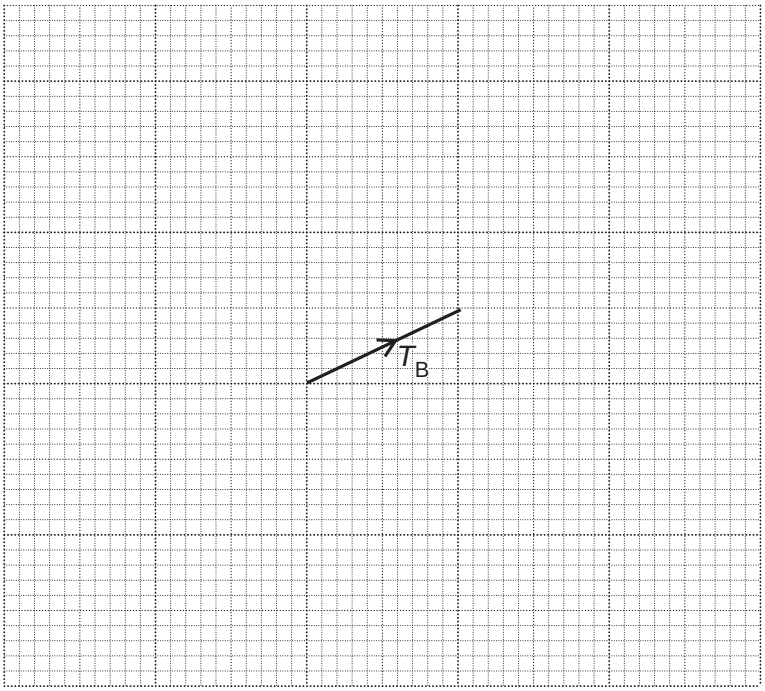

Fig. 6.3

(i) Determine the magnitude of T_B.

T_B = ... N **[1]**

(ii) Draw a triangle of forces on **Fig. 6.3** to represent the forces acting on the cylinder. Determine the magnitude of T_A.

T_A = ... N **[3]**

(iii) Determine the angle θ in **Fig. 6.2**.

θ = ... ° **[1]**

Question 6 continues on page 16

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(c) **Fig. 6.4** shows the same cylinder at rest on a bench.
A horizontal force *F* is applied to the cylinder so that it can rotate about point **X**.

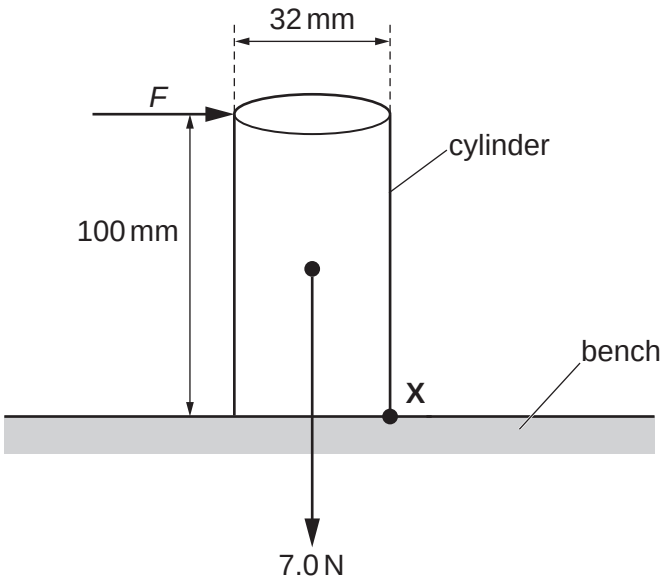

Fig. 6.4 (not to scale)

Calculate the minimum value of *F* to just topple the cylinder about **X**.

F = ... N **[2]**

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Question 7 is on page 18

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7 A 150 W heater constructed from nichrome wire is switched on for 5.0 hours.

The wire has a cross-sectional area of $4.1 \times 10^{-9}\,m^2$.
The current in the wire is 1.5 A.
The number density of charge carriers in nichrome is $7.9 \times 10^{28}\,m^{-3}$.

(a) Calculate

(i) the resistance R of the heater

$R =$ ..... Ω **[2]**

(ii) the number N of electrons passing through the heater in 5.0 hours

$N =$ ..... **[2]**

(iii) the mean drift velocity v of the electrons (charge carriers) in the heater.

$v =$ ..... $m\,s^{-1}$ **[2]**

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(b) The cost of 1 kWh of energy is 16p.
Calculate the cost of using the heater for 5.0 hours.

cost = ... p **[2]**

(c) Nichrome is a metal. Silicon is a semiconductor.

State how the number density of charge carriers n and the resistivity ρ of silicon compare with that of nichrome.

n .....

.....

.....

ρ .....

.....

.....
[2]

Question 8 is on page 20

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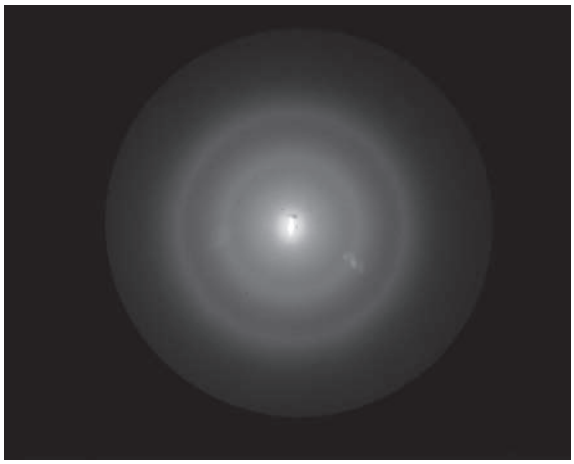
8* A student is investigating electron diffraction. A beam of electrons is directed towards a thin slice of graphite in an evacuated tube.
The electrons are accelerated by a potential difference of 2000 V. The diagram below shows the pattern formed on the fluorescent screen of the evacuated tube.



Describe and explain how the pattern changes as the potential difference is increased. Include how the de Broglie wavelength λ of the electron is related to the potential difference V. **[6]**

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END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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